REPRINTED FROM THE
UNIVERSITY MEDICAL MAGAZINE,
September, 1889.

EXPERIMENTS TO DETERMINE THE VALUE OF OXYGEN IN THE RESUSCITATION OF ANIMALS POISONED BY CO OR ORDINARY COAL GAS.[1]

BY H. A. HARE, M.D.,

Demonstrator of Therapeutics and Instructor in Physical Diagnosis in the Medical Department, and in Physiology in the Biological Department, University of Pennsylvania; Physician to St. Agnes Hospital,

AND

EDWARD MARTIN, M.D.,

Instructor of Operative Surgery, University of Pennsylvania; Surgeon to the Philadelphia and Howard Hospitals; Assistant Surgeon to the University Hospital.

Reprinted from the
University Medical Magazine,
September, 1889.

EXPERIMENTS TO DETERMINE THE VALUE OF OXYGEN IN THE RESUSCITATION OF ANIMALS POISONED BY CO OR ORDINARY COAL GAS.[1]

By H. A. Hare, M.D.,
Demonstrator of Therapeutics and Instructor in Physical Diagnosis in the Medical Department, and in Physiology in the Biological Department, University of Pennsylvania; Physician to St. Agnes Hospital,
and
Edward Martin, M.D.,
Instructor of Operative Surgery, University of Pennsylvania; Surgeon to the Philadelphia and Howard Hospitals; Assistant Surgeon to the University Hospital.

The application of oxygen for the purpose of supporting life, when for any reason the ordinary means of supply are taken away has been employed for quite a number of years in the treatment of crises in pneumonia and kindred diseases where the lung space is considerably contracted by consolidation or pressure. In the experiments which we have made we have found it of so much value in other—accidental—conditions of respiratory failure that we are prepared to recommend its use not only in all those conditions which we have named, but in addition in those cases where ordinary means of artificial respiration are not sufficient to revivify the patient.

In order to prove the efficacy of this gas we have made experiments, the object being to determine exactly how much good is accomplished by its employment, first taking as a common type of such conditions ordinary coal gas poisoning. (See Experiments 1 and 2, 3 and 4, 5 and 6, 7 and 8, 9 and 10, 11, 12 and 13, 14 and 15.)

The method which we employed for the carrying out of these experiments in the case of rabbits and dogs was as follows :—

In all these experiments the animals were placed in a galvanized iron box, of the following dimensions in the case of the rabbits:—38 x 22½ x 22½ centimeters.

The opening where the rabbit was put in was covered by a glass dome so that the experimentor could see the animal.

In the experiment on the dog a perfectly air-tight galvanized iron box with a heavy iron door screwed to it by thumb-screws, and made air-tight by the placing of a rubber pad around the margin, contained the dog. In the upper corner was an opening in which was fitted a tube attached to the city gas sup-

[1] Part of an Essay to which was awarded the Warren Triennial Prize of the Massachusetts General Hospital, June, 1889.

ply, and at the other end of the box was a similar opening through which the atmospheric air was allowed to escape, as the gas rushed in, until the air was displaced, when it was closed. This opening was closed just as soon as gas began to pass out of it. The exact time of turning the gas on was noted down, and the time was also recorded when the dog was taken out. In the first half of each experiment the time of the application of oxygen was carefully noted and every element of fallacy was excluded. As the same dogs were used in each half of the experiment there can be no room for error here. The last experiment of this series was performed to show that the time when the animals were left in the box was just compatible with the continuance of life.

It will be seen that in every case, the use of oxygen brought the animal back to life and general *bien être* much sooner than if it was allowed ordinary air alone. Thus in the first experiment regular diaphragmatic breathing came on within one minute and thirty seconds after the dog was removed from the box, whereas, in the same experiment, in the second half, this regular breathing did not come on until the dog had been out of the box no less than four minutes.

Again, in the first half of the second experiment the dog had virtually recovered in three minutes after he had been removed from the box, but in the second half this state was not reached for four minutes and a half. In Experiments Nos. 2 and 3 regular diaphragmatic respirations came on within one minute, but in the second half with no oxygen, not for three minutes. In the next, normal breathing was established in one minute with oxygen, but not for two minutes and forty seconds when no oxygen was used.

In the last experiment it will be seen that regular breathing came on in two minutes and a half with oxygen, and not for three minutes without oxygen. It is unnecessary to quote the others as they give results virtually identical with those just quoted. The experiments are divided into halves. The first with oxygen, the second without oxygen. Twenty-four hours were allowed to elapse between each half.

Nos. 1 and 2.

1st Half. SHORT HAIRED BLACK DOG, WT. 5 KILOS. 2d Half.

WITH OXYGEN.		WITHOUT OXYGEN.	
2.37.30	In the box.	1.30.00	In box.
2.40.43	Struggling.	1.32.15	Restless.
2.41.20	Howling.	1.34.15	Howling and convulsed.
2.41.40	Quiet.	1.34.50	Quiet.
2.44.00	Out. Oxygen immediately.	1.36.30	Out. Tremors, gasping 3 times in 30 seconds.
2.44.30	One gasp.		
2.45.00	Several diaphragmatic inspirations, very slight.	1.37.15	Extension of neck and gasping 6 times to the minute. Neck muscles pull head forward with each inspiration.
2.45.30	Regular diaphragmatic breathing.		

2.46.00	O. removed, somewhat irregular gasping respirations, 30 to the minute.	1.38.30	Gasping—16 to minute.
		1.40.30	Regular thoracic breathing, diaphragmatic action apparently reversed.
	Oxygen given 2 minutes.		
	Time from exit from box to establishment of normal breathing one minute and thirty seconds.	1.46.00	Regular, rapid, normal breathing.
		1.56.30	Standing, feebly walking.
			Time from exit from box to establishment of normal breathing, 4 minutes.

Animal in box in each instance 6 minutes and 30 seconds.

Nos. 3 and 4.

1st Half. TERRIER, WT. 5 KILOS. 2d Half.

	WITH OXYGEN.		WITHOUT OXYGEN.
2.00.00	In.	1.52.30	In.
2.05.00	Howling.	1.57.00	Howling.
2.05.30	Quiet.	1.58.30	Out.
2.06.00	Out. Oxygen at once.	1.59.00	Has given two gasps.
2.67.00	6 Gasps in the minute. Heart 60, 1st 3 gasps 15 seconds apart.	1.59.15	2 gasps.
		2.00.00	2 gasps.
2.08.00	Eye reflex is all right, head extended, a slight moaning.	2.01.00	6 gasps.
		2.02.30	Head extended, thoracic breathing, but somewhat irregular. Diaphragmatic action apparently reversed.
2.09.30	Respirations 60 to minute, full, deep and regular.		
2.09.00	Normal walking.		
	Oxygen given 3 minutes.	2.03.00	Regular diaphragmatic breathing.
	Time between exit from box and establishment of regular respirations 3 minutes. Time between exit from box and restoration of voluntary motion 3 minutes.	2.11.00	Wags tail when spoken to and can just stand. Time between exit from box and establishment of regular respirations 5 minutes 30 seconds. Time between exit from box and restoration of consciousness and voluntary movement 13 minutes

Time in box 6 minutes.

Nos. 5 and 6.

1st Half. TERRIER, WT. 5 KILOS. 2d Half.

	WITH OXYGEN.		WITHOUT OXYGEN.
2.12.30	In.	2.20.00	In.
2.17.00	Howling, struggling.	2.80.00	Out.
2.17.15	Quiet.	2.90.00	Gasping respirations 4 in first minute.
2.18.30	Out. Oxygen.		
2.19.00	Has given 3 deep respirations, thoracic in character.	2.90.30	Gasping respirations, slow 8 to minute, with short, diaphragmatic respirations between.
2.19.30	Regular diaphragmatic respirations.	2.11.00	Regular breathing and retraction of head and extension of forelegs.
2.19.45	Head rigidly retracted.		
2.20.15	Oxygen removed.		
	Oxygen given 1 minute and 46 seconds.	2.15.00	Semiconscious. Breathing mainly diaphragmatic.
	Time between exit from box and establishment of regular respirations 1 minute.	2.16.00	Feeble efforts at standing.
			Time between exit from box and establishment of regular respirations 3 minutes.

Animal in box in each instance 6 minutes.

Nos. 7 and 8.

1st Half. SHAGGY BITCH, WT. 9 KILOS. 2d Half.

WITH OXYGEN.		WITHOUT OXYGEN.	
3.25.30	In.	2.24.30	In.
3.30.30	Howling.	2.29.30	Howling.
3.31.30	Out. Oxygen at once, 4 gasps to minute.	2.29.45	Quiet.
		2.30.30	Out.
3.32.30	Is breathing normally. Oxygen stopped, eyelid reflex perfect.	2-31.30	8 thoracic respirations. Not gasping, very deep, irregular.
3.36.00	Wags tail when spoken to.	2.32.15	Rigid extension of head, and forelegs.
3.37.00	Has vomited glairy liquid about 10 c.c.	2.33.10	Normal breathing.
	Oxygen given one minute.	2.36.00	Wags tail when spoken to.
	Time from exit from box till establishment of normal breathing one minute.		Time from exit from box to establishment of normal breathing 2 minutes and 40 seconds.

Time in box 6 minutes.

Nos. 9 and 10.

1st Half. BROWN SPANIEL, WT. 8 KILOS. 2d Half.

WITH OXYGEN.		WITHOUT OXYGEN.	
3.15.00	Put in.	12.16.00	In.
3.19.00	Whining.	12.20.15	Whining.
3.21.00	Taken out. Gasps 2 in minute.	12.22.00	Out, gasping irregular respirations carried on mainly by neck muscles.
3.23.30	Stopped O. Breathing regular, diaphragmatic.		
3.31.00	Is wagging tail.	12.24.30	Slow, gasping respirations 6 to minute. Chest motion well marked.
	Normal breathing in 2 minutes and 30 seconds.		
		12.25.00	Regular chest and diaphragmatic respirations; eye reflex returning.
		12.25.30	Slight retraction of head.
		12.26.00	Eye reflex established.
		12.41.00	Consciousness returning, head raised on calling.

Time in box 6 minutes.

No. 11.

SHAGGY DOG, WT. 3.8 KILOS.

2.27.00	In.	2.31.45	Quiet.
2.30.30	Howling.	2.34.00	Out. No respiratory movements.
2.31.00	Struggling and howling.	2.34.10	Dead.

This experiment shows that a period of exposure greater than was usual would result fatally.

Nos. 12 and 13.

1st Half. RABBIT, WT. 1 KILO. 2d Half.

WITH OXYGEN.		WITHOUT OXYGEN.	
1.34.40	Gas turned on.	12.54.30	Put in box and gas turned on.
1.36.30	Slight convulsive movements.	12.56.30	Staggering and rubbing at nose with paws.
1.36.40	Lies on one side.		
1.37.00	Convulsions.	12.56.45	Convulsive running movements.
1.37.10	Lies on side with full diaphragmatic breathing.	12.57.00	Quiet. Full diaphragmatic breathing.

1.38.40	Taken out. Slow breathing.	12.57.15	Squealing but lying motionless on side.
1.38.45	Oxygen given.		
1.39.30	Breathing naturally and is hopping about.	12.57.45	Ditto.
		12.58.00	Gasping.
	Volume of gas in each instance is 0.208 cubic feet.	12.58.30	Taken out of box. Gasped 4 times, then respiration ceased. Dead.

Time in box 4 minutes.

Nos. 14 and 15.

RABBIT, WT. 1½ KILOS.

1st Half. With Oxygen.		2d Half. Without Oxygen.	
2.36.00	Put in box.	12.41.00	Put in box and gas turned on.
2.37.45	Feeble running convulsions.	12.43.15	Respiratory excitement with rubbing of nose with the paws.
2.38.00	Convulsions have ceased.		
2.38.45	Slow gasping respirations, 20 to minute.	12.43.25	Convulsive movements (running movements, with forelegs.
2.39.00	Respirations are getting slower.	12.43.35	Convulsion has ceased, lies upon side, has deep diaphragmatic breathing.
2.39.45	12 a minute.		
2.40.00	Taken out of box.		
2.40.15	Oxygen.	12.44.30	Convulsive movements repeated.
2.41.30	Respirations are 24. Eye reflex has returned.	12.45.00	Taken out of box. Pupils moderately dilated. Respirations 10.
2.47.00	Has recovered and can sit up, but is still weak.	12.57.30	Is up and hopping around feebly. The bloodvessels of the ear are intensely engorged, ocular reflex returned.
	Volume of gas 0.208.		Volume of gas 0.208.

Time in box 4 minutes.